

THE WEATHER AND CIRCULATION OF APRIL 1961¹

Persistent Blocking in Eastern Canada and Cool Weather in the United States

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1. WEATHER HIGHLIGHTS

The mild weather of March 1961 in the United States [1] underwent a sharp reversal in April as temperatures changed to below seasonal normals over most sections. Average temperatures also contrasted in many areas with those of April 1960 [2] which had been predominantly mild in the United States. Both Aprils were similar, however, in that each had reversals near mid-month with cooling in the West and warming in the East in the latter part of the month.

It was the coldest April since 1907 in much of the Southeast, as well as the coldest on record in parts of Alabama, where Montgomery reported a monthly average of 60.2° F., the lowest in 89 years. In the West unseasonably low temperatures produced freezing minima on a number of days near the middle and latter parts of the month with damage to orchard crops in many regions. In Montana and Wyoming this was the first month since August 1960 that temperatures averaged below normal.

This was not only a cold month but also a wet one in many parts of the East, drastically retarding spring planting operations in many places. It was the wettest April of record in portions of Alaska, North Dakota, New York, Ohio, and Rhode Island. In North Dakota, Bismarck and Fargo reported the first beneficial excess of precipitation since the first of the year.

By way of contrast, this was the driest April on record in some areas of central and southern Texas. The dryness approached drought conditions there, as well as in other parts of the Southwest such as at Phoenix, Ariz., Point Arguello, Calif., and Reno, Nev., where deficiencies of precipitation have been reported for the past five or six months.

Snow fell in record amounts for April in many places, e.g., Caribou, Maine, Youngstown, Ohio, and Muskegon, Mich., while record 24-hour amounts for April of from 11 to 12 inches were reported at Grand Rapids, Mich., and Duluth, Minn., in association with a slowly moving storm between the 14th and 16th. For the winter season as a

whole, record accumulations of snowfall were recorded at Williamsport, Pa., (80.2 in.) and Akron, Ohio, (81.5 in.). In contrast, Green Bay, Wis., had its smallest winter snowfall on record.

A deep storm on the 12th produced the lowest sea level pressure (989 mb.) ever recorded in April at Louisville, Ky. It was accompanied by winds of over 100 m.p.h. at Sullivan and Edisto Islands near Charleston, S.C., and tornado damage at James Island, S.C. Tornado reports were numerous in the last 10 days of the month in the climatologically famed "Tornado alley" extending from Oklahoma to Iowa. Tornadoes were also numerous, particularly on the 12th and 15th in the Southeast, where the expectancy is much less than in the Mid-West.

Moderate to major flooding continued in various parts of the Mississippi Basin, in many of the same areas which were in flood during the preceding month [1].

2. THE MONTHLY CIRCULATION

The monthly average circulation at 700 mb. (fig. 1) and at sea level (fig. 2) for April 1961 was featured by strong blocking in eastern Canada and the polar regions with additional blocking in the Pacific. This was reflected in above normal height departures in these areas at 700 mb. (fig. 1) and a strong High centered near the North Pole at sea level (fig. 2). Mean 700-mb. heights over Baffin Island averaged 460 feet above normal, the largest departure in the hemisphere this month. A departure of this magnitude in the Canadian area has been exceeded only once in any April since 1933. A departure of 610 feet was observed in April 1953 [3], which was similar to this April in respect to the coolness over much of the United States, as well as other features.

Figure 3 shows the well-marked changes in the 700-mb. circulation (in excess of the normal changes) which occurred between March and April 1961. Large height rises in the Gulf of Alaska and falls over the Great Lakes set up an abnormally strong flow of cool air from northwestern Canada into the southeastern United States. Strong rises in the Baffin Island area almost completely reversed the flow in this area, while strong height falls near the United Kingdom reflected a cessation of the blocking which occurred there during March [1]. The

¹ Descriptions of the weather of May, June, and July 1961 will appear in the August, September, and October issues of the *Monthly Weather Review*, respectively.

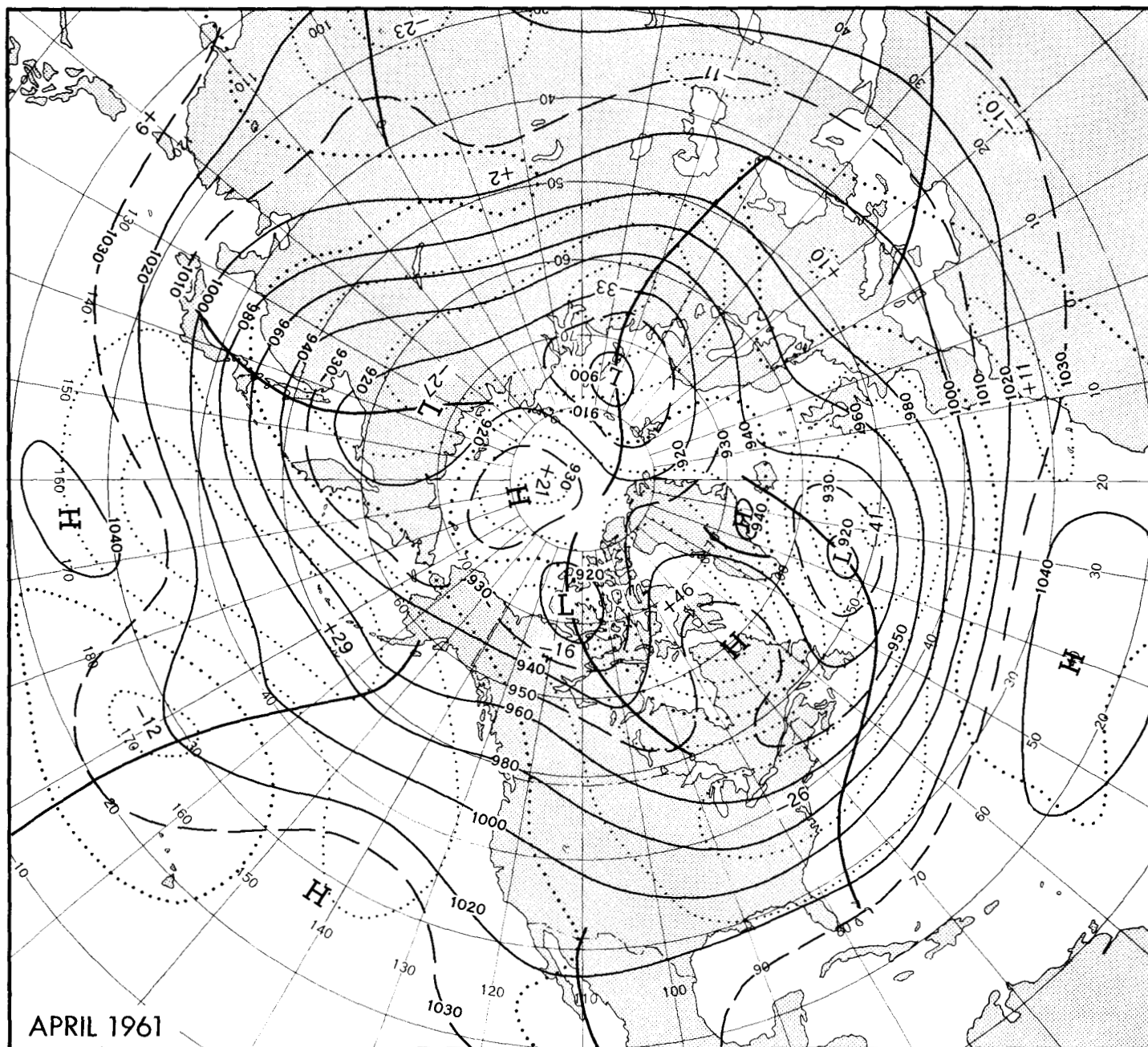


FIGURE 1.—Mean 700-mb. contours (solid) and departures from normal (dotted) (both in tens of feet) for April 1961. Blocking of near record intensity in eastern Canada had a major influence on weather in the United States.

retrogression of this block to North America is evident in the movement of a height rise area, which was located just south of Greenland in March (fig. 6 of [1]), to the Baffin Island area in April (fig. 3), and subsequently, westward across Canada as shown in figure 4.

Despite extensive blocking in the western sector of the hemisphere (0° – 180° W.), the average speed of the westerlies between latitudes 35° N. and 55° N. was almost exactly normal in April (8.3 m.p.s. at 700 mb. and 2.4 m.p.s. at sea level). The diminution in wind speeds

(about 7 m.p.s. below normal at 700 mb.) associated with blocking occurred primarily in southeastern Canada and the North Atlantic, as well as in the central Pacific, but it was compensated by much stronger than normal westerlies in the Atlantic, where 700-mb. wind speeds averaged as much as 21 m.p.s., or about twice the normal speed, between 35° N. and 45° N. In the subtropics (20° N.– 35° N.) wind speed indices also averaged near normal at both sea level and 700 mb. Only in the polar (55° N.– 70° N.) wind speed averages was the anomalous

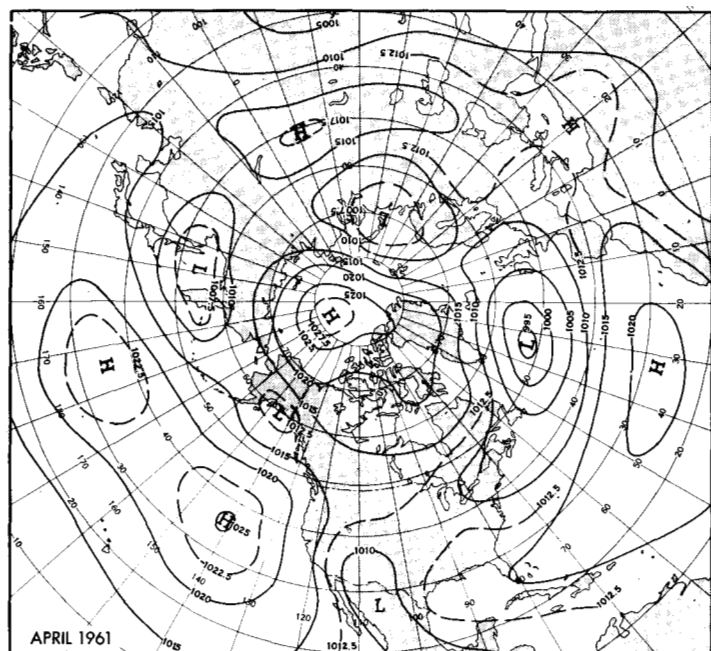


FIGURE 2.—Mean sea level isobars (with intermediate isobars dashed) (in millibars) for April 1961. Widespread anticyclonic activity dominated the polar region, while the marked trough from the southern Rockies to New England reflects the locus of vigorous cyclonic activity.

nature of the circulation clearly revealed. At 700 mb., for example, the westerlies averaged 1.1 m.p.s. below normal, while at sea level the easterlies averaged 3.2 m.p.s. or twice the normal value for April. This abnormality was related to the excessive easterly components of the average flow, relative to normal, in eastern North America and the North Atlantic. This is revealed by figure 1 which shows the axis of positive height departures located at 70° N. in eastern Canada and Greenland, while the axis of negative departures extended from 50° N. in the Atlantic to 40° N. in North America. The mean sea level pressure averaged at each latitude in the 0°–180° W. sector showed above normal pressures north of about 55° N. and below normal pressures to the south, a similar profile to that shown in figure 1 of [3] for April 1953.

The eastern Canadian block was associated not only with a marked weakening of westerlies in this area, but also, as revealed by figure 1, with an actual high center at 700 mb. in the monthly average. This was a noteworthy abnormality in view of the fact that eastern Canada is the location of a deep cyclonic center of action in the long-period circulation averages. No closed high centers in the monthly average circulations at 700 mb. have heretofore been observed in this area in any April in the historical files of Extended Forecast Section which date back to 1933, although about 10 cases with 5-day mean high circulations in this area were observed between 1947 and 1958. On a daily basis, high centers aloft in

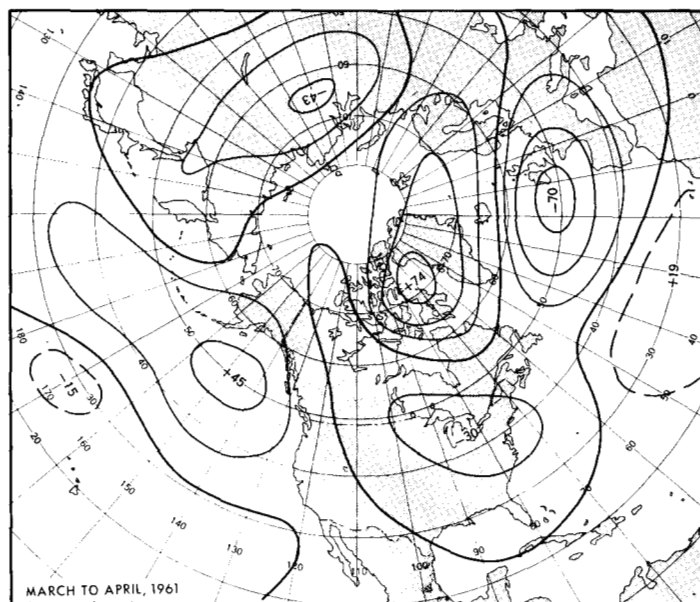


FIGURE 3.—Anomalous 700-mb. height changes (tens of feet) between March and April 1961 with zero line heavier. Falls over the Great Lakes and rises in the eastern Pacific produced a sharp reversal in the circulation and associated temperature regime over large areas.

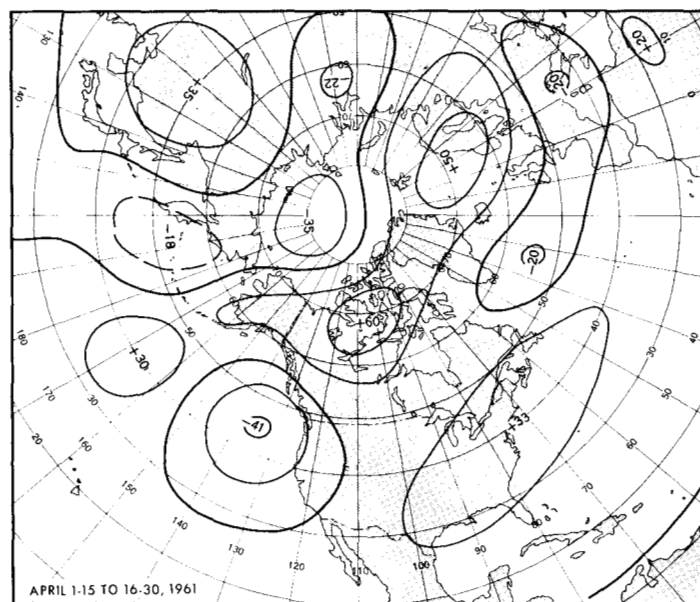


FIGURE 4.—Mean 700-mb. height changes (tens of feet) between the first and last halves of April 1961 (see fig. 5). Lowering of heights in the eastern Pacific and increase of heights east of the Rockies were associated with cooling over the Rockies and warming to the east in the latter half of the month.

this area were observed on over half the days during this month, in addition to ridge conditions on some other days.

The abnormality of the circulation in Canada is dramatized by the extreme temperature departures from

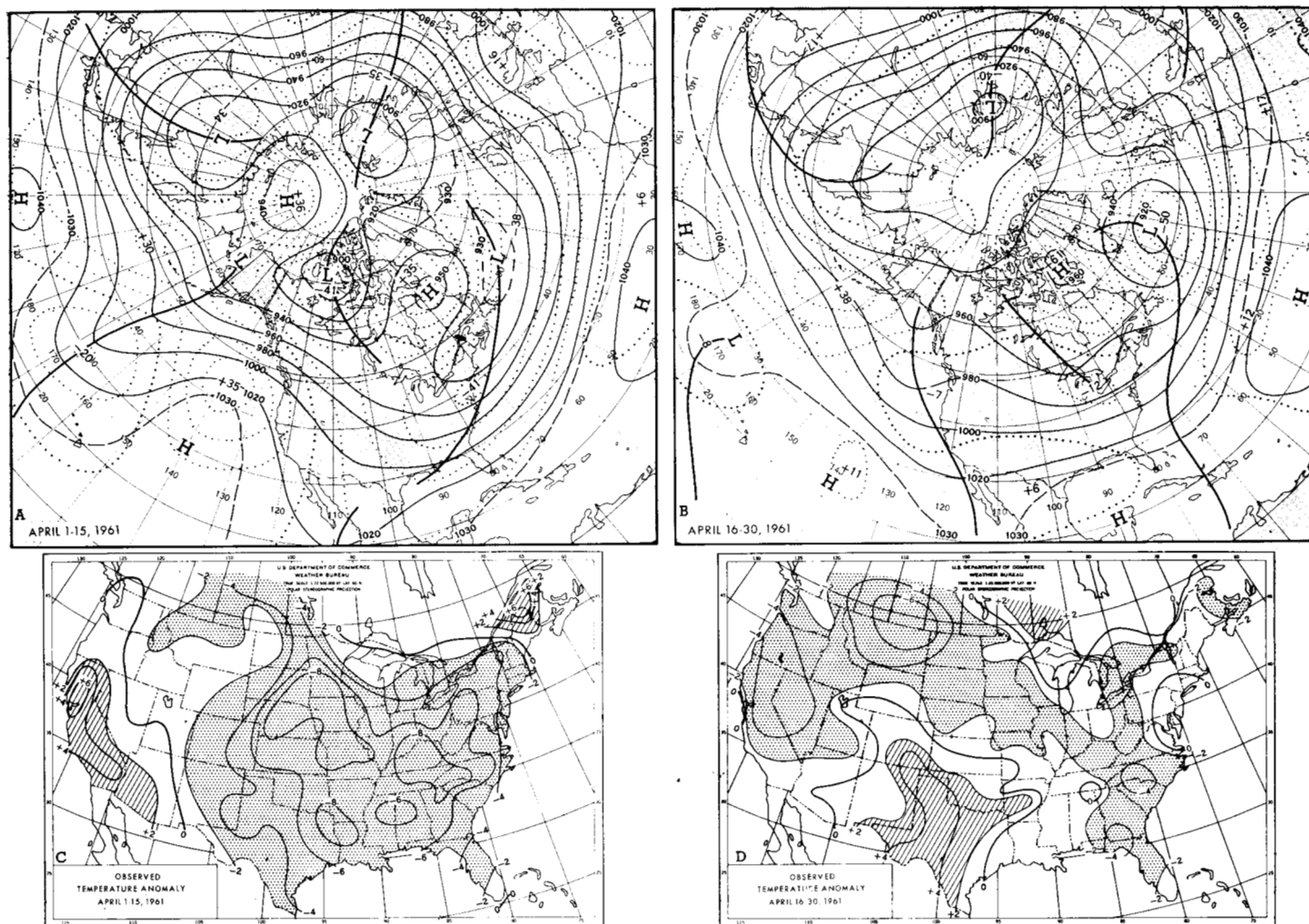


FIGURE 5.—(A) (B) Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for April 1–15, and April 16–30, 1961, respectively. (C) (D) Mean temperature departure from normal ($^{\circ}\text{F}.$) for April 1–15, and April 16–30, 1961, respectively. Trough development along the west coast permitted warming east of the Rockies and cooling in the Far West during the second half of the month.

normal. Temperatures for the month averaged as much as $12^{\circ}\text{F}.$ above normal in southeastern Canada and over $12^{\circ}\text{F}.$ below normal in northwestern Canada. Extreme dryness in eastern Canada also characterized the area of persistent blocking anticyclonic circulation.

In the Pacific the zone of above normal heights centered in the Aleutians was a manifestation of recurrent propagation of anticyclonic vorticity, tending to maintain cyclonic activity at lower latitudes northwest of Hawaii.

3. THE HALF-MONTHLY CIRCULATIONS

Although both halves of April 1961 were characterized by blocking in eastern North America and the north Pacific, continuity of long-period retrogression of major height change centers at higher latitudes was still evident.

Figure 4 shows the height changes which occurred between the first and last halves of April. Comparing these with figure 3, it appears that the Baffin Island block, which had previously retrograded from the North Atlantic, continued westward across Canada, while the Gulf of Alaska block retrograded toward the central Pacific. Replacing the retrograding Gulf of Alaska block in the second half of the month was a 410-foot height fall center off the Pacific Northwest coast, in precisely the location of a strong ridge in the first half of the month.

Figures 5 A and B show the circulations in the first and last halves of the month with the 700-mb. height departures superimposed. The northern part of the full-latitude trough of the first half-month in the central Pacific sheared and was forced eastward by progression of the Asiatic trough at higher latitudes. The sheared trough subsequently combined with the low-latitude

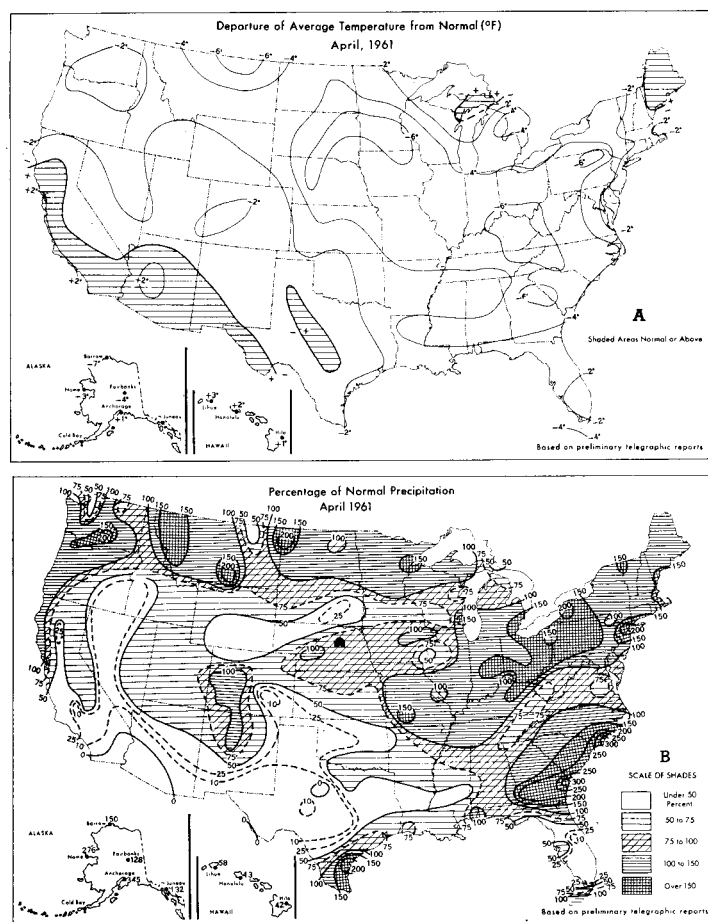


FIGURE 6.—(A) Mean temperature departures from normal ($^{\circ}\text{F}$) for April 1961. (B) Percentage of normal precipitation for April 1961. (From [4].)

trough near Baja California. The lowering of heights associated with this trough amalgamation along the west coast was reflected downstream in the pattern of rising heights over the Middle Atlantic States in figure 4. These rises resulted in considerable filling of the eastern United States trough in the last half of the month. However heights still remained below normal with depressed westerlies in the East, a common manifestation of blocking conditions at higher latitudes.

4. AVERAGE WEATHER IN THE UNITED STATES TEMPERATURE

Temperatures averaged cooler than normal over most of the United States except Hawaii, Maine, and parts of the Southwest, as shown in figure 6A. The coolest air, relative to normal, extended from Montana southeastward to the Appalachians, ranging to 6°F . or more below normal in upper Montana, the northern Plains, Pennsylvania, the Ohio Valley, and the southern Appalachians. This pattern was in close agreement with the negative height departures at 700 mb. (fig. 1) and the direction of

anomalous flow from western Canada and Alaska. This flow had additional support from the abnormally strong ridge in the eastern Pacific which helped transport cold polar air southward into the United States.

Persistence of the temperature pattern from the previous month, expressed as a percentage of 100 stations not changing by more than one class (out of five) was only 32, compared with average March to April persistence of about 65 percent from 1942 to 1960. This comparison dramatizes the magnitude of the change in regime over North America, due in part to retrogression of blocking from its position over the Atlantic during the previous month.

The average temperature departures for the first and last halves of April are shown in figures 5 C and D. Marked cooling in the Far West and warming in the East are explained in large part by the lowering of heights and trough development near the west coast, and rising heights with resulting partial filling of the trough near the east coast, shown by the height change pattern in figure 4. The relatively larger warming over Texas, where temperatures rose to well above normal in the latter half of the month, may be due, at least in part, to the extreme dryness there, tending to make this region act as a heat source.

PRECIPITATION

Precipitation this April (fig. 6B) was heavier than normal throughout most of the northern border States, and also from the middle Mississippi Valley across Ohio to the Northeastern States. Another area of very heavy precipitation included Georgia and the Carolinas. Above normal precipitation also occurred in the southern part of the Continental Divide and extreme southern Texas. Elsewhere precipitation was mostly less than normal, with dry conditions approaching drought in many parts of the Southwest and Southern Plains, as well as in parts of the Florida peninsula where the driest April on record was reported. The heavy precipitation areas were closely associated with the prevailing depressed tracks of cyclonic activity, which was generally of a vigorous nature. These tracks are clearly suggested by the trough in the monthly sea level chart (fig. 2) and the negative height departure pattern of the 700-mb. contours (fig. 1). Very heavy precipitation, much of it in the form of snow, occurred in Alaska and was related to below normal temperatures and frequent storminess, as indicated by the mean Low there at sea level (fig. 2).

5. WEATHER EVENTS BY 5-DAY PERIODS

APRIL 1-5

During this period an extremely deep trough aloft near the east coast combined with an abnormally strong ridge near the west coast to bring much cooler air than normal to the eastern half of the United States, with average temperature departures as much as 10°F . in the Appalachian area. The West enjoyed warmer conditions, ranging

to 10° F. above normal in California and parts of Nevada. Hottest temperatures for so early in the spring were reported in some areas such as Yuma, Ariz., where temperatures reached 104° F. Precipitation was generally moderate in eastern and northern sections, although rains in excess of an inch fell in parts of New England in connection with a deep storm that emerged from the Gulf States.

APRIL 6-10

During this period retrogression of large-scale circulation features over the United States was accompanied by an influx of much colder than normal air into western and central sections, ranging on the average to 16° F. below normal in the Central Plains, with above normal temperatures in the country confined to the extreme corners. Heavy precipitation, totaling from ½ inch to well over an inch, occurred in many places from Nevada eastward to the east coast during the passage of a vigorous Low from the southern Rockies to the Mid-Atlantic coast. Snowfall ranging up to 12 inches fell in the Central Plains, and rains up to 2 inches along the Gulf coast accompanied this storm system.

APRIL 11-15

Below normal temperatures persisted during this period from coast to coast, with widespread heavy precipitation over most sections of the country (except the dry Southwest) due to a deep trough in the central part of the country with a strong ridge off the west coast. Temperatures averaged as much as 10° F. below normal in the Central Plains.

The heavy precipitation, over an inch generally in the East and ranging to 3 and 4 inches in the Southeast, accompanied by tornadoes and severe windstorms, was produced by a rapidly deepening storm which traversed this area from the southern Rockies. This storm produced over a foot of snow in some places in the Central Plains, and farther east it yielded the record low pressure of 989 mb. at Louisville, Ky., on the 12th. On this day Huron, S. Dak., recorded a minimum temperature of 6° F., the lowest ever recorded there in April.

Another deep storm traversed the upper Mississippi Valley on the 14th and 15th, bringing heavy precipitation to that area, including about a foot of snow.

APRIL 15-19

In this period shearing of the central Pacific trough carried its northern portion eastward into the Gulf of Alaska, which forced the eastern Pacific ridge inland over the Rockies and the central United States trough eastward to the Appalachians. This eastward motion produced warming to above normal temperatures west of the Continental Divide, while below normal temperatures continued to dominate the country east of the Rockies, averaging as much as 11° F. below normal in some parts. The coldest temperatures for so late in the season occurred in parts of Texas and Louisiana, especially on the 16th.

The warmer air in the West spread eastward from the

Rockies, reaching the Mississippi Valley on the 19th. Temperatures ranged up to 21° F. above normal in the Dakotas, with an all time high temperature for so early in spring of 83° F. on the 19th at Denver, Colo. Another mass of very cool Pacific air, as much as 16° F. below normal in Oregon, followed in the wake of this warm air, reaching Salt Lake City on the 19th, accompanied by heavy precipitation in the Pacific Northwest.

Precipitation was heavy from the Mississippi Valley eastward from the same deep storm system of mid-month which slowed down over the Great Lakes Region.

APRIL 20-24

This was the only extended period during the month which departed radically from the monthly mean circulation and temperature regime. During this time a deep mean trough was situated in the Far West with a stronger than normal ridge in the East. Blocking still persisted in eastern Canada, however, but was somewhat diminished in strength. Because of the prevailing southwesterly flow over much of the United States, precipitation was generally heavy from coast to coast north of about 37° N. However, it was largely dry to the south, except in California where heavy rains associated with the deep coastal mean trough extended southward into the southern part of that State.

Temperatures were above normal east of the Continental Divide, averaging as much as 15° F. above normal at Oklahoma City, while, in the West, temperatures averaged as much as 12° F. below normal in Nevada and California. These conditions were favorable for above normal tornado activity in the central sections of the country.

On the 23d the cool Pacific air was centered near Ely, Nev., where temperatures averaged 20° F. below normal that day, while the leading edge of the cool air advanced across the North Central States to the Great Lakes. At this time very warm temperatures, ranging up to 17.5° F. above normal near Amarillo, Tex., stretched eastward to the Mid-Atlantic States, just south of a strong jet stream and polar front. By the 24th the cool Pacific and Canadian air stretched from the southern Continental Divide to the upper Great Lakes, with an active tornado-producing wave cyclone traveling across Iowa toward the Great Lakes. Temperatures in the warm air reached 18° F. above normal in Ohio at this time.

APRIL 25-30

In this period the circulation again reverted to the characteristic monthly regime of trough in the East and ridge in the West, with cooler than normal air practically from coast to coast, averaging as much as 13° F. below normal in the Dakotas and Minnesota. Precipitation during the period was heavy in the East and in most northern border areas.

On the 25th the cool air spread from the lower Great

Lakes region southwestward to Texas, reaching 14° F. below normal in Arizona, while another mass of very cool Canadian air entered Montana. The warm air in the East at this time was attended by a temperature of 91° F., or 20° F. above normal, at Richmond, Va. This was reminiscent of the record warmth in April 1960 when the temperature reached a record 96° on the 26th. These strongly contrasting air masses were associated with another active frontal cyclone which traveled from the Panhandle to the Great Lakes. By the 27th the cool air had swept eastward and stretched from coast to coast, ranging to 19° F. below normal in North Dakota. On the 28th and 29th, warm air was again spreading over the Rockies and southeastward into Texas, where temperatures reached 15° F. above normal on the 30th. On the last day of the month another influx of cold Canadian

air entered the North Central States, with temperatures as much as 16° F. below normal in North Dakota.

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